THE MODIFIED CHICKASHA SEDIMENT SAMPLER

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CONTENTS

ILLUSTRATIONS

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THE MODIFIED CHICKASHA SEDIMENT SAMPLER

By Paul B. Allen, Norman H. Welch, Edd D. Rhoades, Carlton D. Edens, and Gary E. Miller,[1]

ABSTRACT

A fully automatic sampler has been developed to collect samples of sediment-laden runoff. The sampler is especially suited for small watersheds where manual sampling is impractical because of remoteness or flashiness of runoff or where a complete concentration graph is needed for each runoff event. The sampler holds 28 pint bottles and is powered by a 12-volt battery. In most installations, the sampler is turned on or off by a float switch when the stream rises above or falls below a preselected level. Each sampling event, controlled by a 2-minute timer, consists of a bottle tray advance, a pumping period of approximately 1 minute, and near the end of the pumping period, a flow diversion into a bottle. Sampling events may be initiated by a clock-driven sampling-frequency wheel that has fixed time intervals or progressively lengthened time intervals to suit the particular watershed. Sampling may be controlled with an alternate device that initiates an event each time the stream rises by a fixed amount or falls by some other fixed amount.

INTRODUCTION

This publication describes an automatic pump-ng sediment sampler, designed and constructed .t the Southern Great Plains Research Water-hed, Agricultural Research Service. An earlier 'ersion of the sampler was described by Miller t al.[2] Modifications of the original sampler in-lude changes in the electrical circuit, substitu-ion of a different pump and motor, substitution 'f an improved on-off float-switch assembly, and nclusion of an optional method to initiate a ampling event. The sampler was developed to implement the location's mission of determining the effects of upstream flood-control treatment on downstream areas.

One of the factors to be considered in designing effective flood-control treatments is the effect of land use on runoff and sediment production. Therefore, a number of small watersheds were established to investigate the effect of land use on hydrologic performance, including erosion rates and water quality.

Manual collection of suspended-sediment samples from these small watersheds was not satisfactory. Spring and summer rainstorms in the southern Great Plains are often short and intense, and runoff usually follows quickly after a storm begins. Also, most runoff events occur outside normal duty hours. It is almost impossible to be at these watersheds in time to obtain initial samples. The use of an automatic sampler was the only practical method of collecting sediment samples, especially during the initial period of runoff. This led to the development of a sampler particularly suited to the project at Chickasha. The sampler is patterned after the

[1] Research hydraulic engineer, soil scientist, agricul-ural engineer, and hydraulic engineering technician, outhern Great Plains Research Watershed, Agri-ultural Research Service, U.S. Department of Agricul-ure, Chickasha, Okla. 73018, and hydraulic engineering echnician, Water Quality Management Laboratory, gricultural Research Service, U.S. Department of griculture, Durant, Okla. 74701.

[2] Gary E. Miller, Paul B. Allen, Norman H. Welch, nd Edd D. Rhoades. The Chickasha Sediment Sampler. J.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS 41-150, une 1969, 14 pp.

XPS–62 sampler developed by the Federal Inter-Agency Sedimentation Project.[3]

GENERAL OPERATION

Figure 1 shows an overall view of the Chickasha sediment sampler. The sampler, capable of collecting up to 28 samples in 12 hours, is powered by a 12-volt automotive battery. It is activated by a water-level sensor (WLS), which may be set at any predetermined stage. With a rise in stage to the preselected level, the WLS closes, permitting electric current to flow from the 1.5-volt dry-cell battery (B2) to the sampling-frequency drive (SFD). A sampling-frequency wheel is attached to the drive, which rotates counterclockwise. The sampling interval (or a combination of intervals) can be selected for individual watersheds. Rotation of the sampling-frequency wheel by the drive allows the switch lever to drop into the first notch, completing the circuit of the 2-minute timer motor (M1).

An alternate apparatus to initiate sampling is a light-activated unit.[4] It allows sampling at different stage-change intervals during the rise and recession of flow. For example, a stream can be sampled at 0.5-foot intervals on the rise and 1-foot intervals on the recession or at several other combinations. Multiple-peak storms will be sampled at these intervals, providing better sample distribution than at time-controlled sampling intervals. The light-activated unit performs the same function as the sampling-frequency drive by completing the circuit to the 2-minute timer motor (M1).

The sequence of events needed to collect a sample is programed through four cam-operated switches attached to the timer motor. First, the tray-advance solenoid (RS1) is energized, placing a bottle in position to receive a pumped sample. Following the tray advance, the pump motor (M2) operates for approximately 1 minute. During most of this pumping period, flow is discharged back into the stream. This flushes the line of all sediment-laden water from pre-

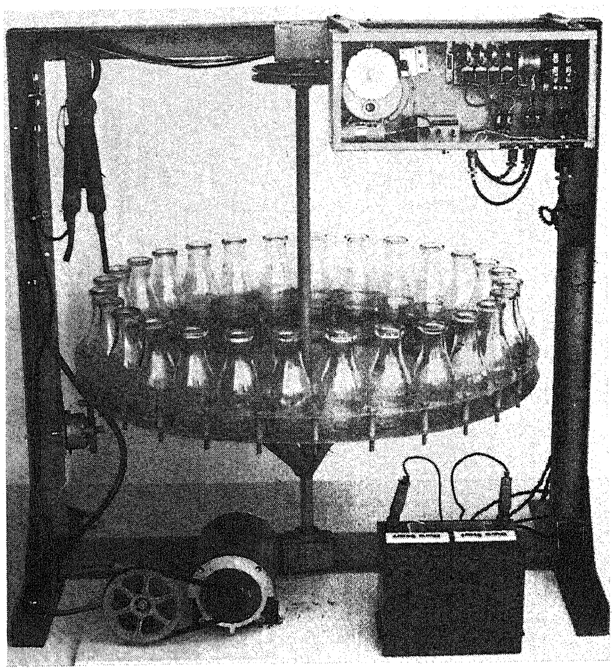


FIGURE 1.—Chickasha automatic pumping sediment sampler.

vious pumping. Near the end of the pumping period, the flow-diverter solenoid (RS2) is energized, causing the pumped flow to be discharged into a sample bottle. The time required to fill the sample bottle to the proper level varies with differences in the pumping head but may be obtained by adjustment of the proper cam-operated switch. The chart pipper solenoid (RS3), or flow-chart-marking mechanism, is energized at the same time as the flow diverter.

When the sequence of events is completed, the timer motor (M1) is stopped by cam-operated switch S1. Since the timer motor completes its rotation before the sampling-frequency switch (FS) moves out of each notch, a control relay (K4) is needed to prevent more than one sample from being taken per notch. The timer motor is activated again when the sampling-frequency switch drops into the next notch on the sampling-frequency wheel or when the stream rises or falls the selected interval, if controlled by the light-activated unit. The sampling procedure is repeated until the tray-drive weight opens switch S5 positioned at the lower end of the weight guide tube, stopping the sampler. The WLS will also stop the sampler if the stage drops below the predetermined level. When all bottles are filled or when the WLS shuts off the current, the tray is ready to be emptied and reset.

[3] Investigation of a Pumping Sampler With Alternate Suspended-Sediment Handling Systems. Report Q. Federal Inter-Agency Sedimentation Project, June 1962, 90 pp.

[4] Carlton D. Edens and Donn G. DeCoursey. A Dual-Interval, Light-Activated Signal Generator — Its Application to Sediment Sampling. Trans. ASAE 18(5): 505–507 (1975).

THE PUMPING SYSTEM

The pumping system includes a small peristaltic pump, intake and discharge lines, and a flow-diverter mechanism. The intake and discharge lines are latex and copper tubing with an inside diameter of three-eighths inch.

The pump delivers up to 0.8 gallon per minute and is driven by a ¼-horsepower, 12-volt d.c. motor. The pump is self-priming under 16 feet of suction lift. This usually permits its placement inside the sampler house. This is an excellent pump for handling abrasive sand because the pumped material is always within the tubing and never contacts metal surfaces.

If the sediment load has less than 10 percent sand, the smaller, less expensive pump and motor listed as an option in figure 2 can be used. It will prime itself satisfactorily at a suction head of up to 3 feet, but some difficulty was experienced when the suction head was greater. This pump should be located near the water surface for ease in priming. If water level fluctuations might submerge the motor, a suitable stationary pump mounting and an airtight protective cover should be used to permit the pump to be located near the normal water surface (fig. 3). Should the water level rise above the pump, the air compressed inside the cover will not allow water to reach the electric motor. The pump will operate at a discharge head of up to 23 feet.

Various types of pumps have been tested with this sampler. The pumps specified in figure 2 have proved to be satisfactory; however, other pump and motor combinations with comparable electrical and pumping capacities could probably be usd. A TAT model 610 pump and motor is being used by the Agricultural Research Service at Tucson, Ariz.

THE SAMPLER

The frame supporting the components of the sampler is made of 2½-inch angle iron welded together as shown in figure 4.

The bottle tray is made by connecting an aluminum plate 36 inches in diameter to a ring of the same diameter (fig. 5). The ring serves as a guide for positioning the bottles. The plate and ring are held together by two circular rows of bolts with aluminum tubing spacers. The outside row of bolts consists of twenty-eight 3-inch by 5/16-inch bolts spaced equally between each bottle position. The extra length of these bolts is an integral part of the tray-advance mechanism.

The tray is held stationary by the leading arm of a tray-stop assembly attached to the tray-advance solenoid (fig. 6). When the solenoid is energized, the stop assembly rotates 45° counterclockwise, moving the tray clockwise to allow the lower end of the 3-inch bolt to pass over the leading arm of the stop assembly. The tray-advance weight (fig. 4) then rotates the tray counterclockwise until the lower end of the bolt engages the trailing arm and stops the tray. When the solenoid is deenergized, the tray moves counterclockwise until the end of the next bolt comes in contact with the leading arm of the tray-stop assembly.

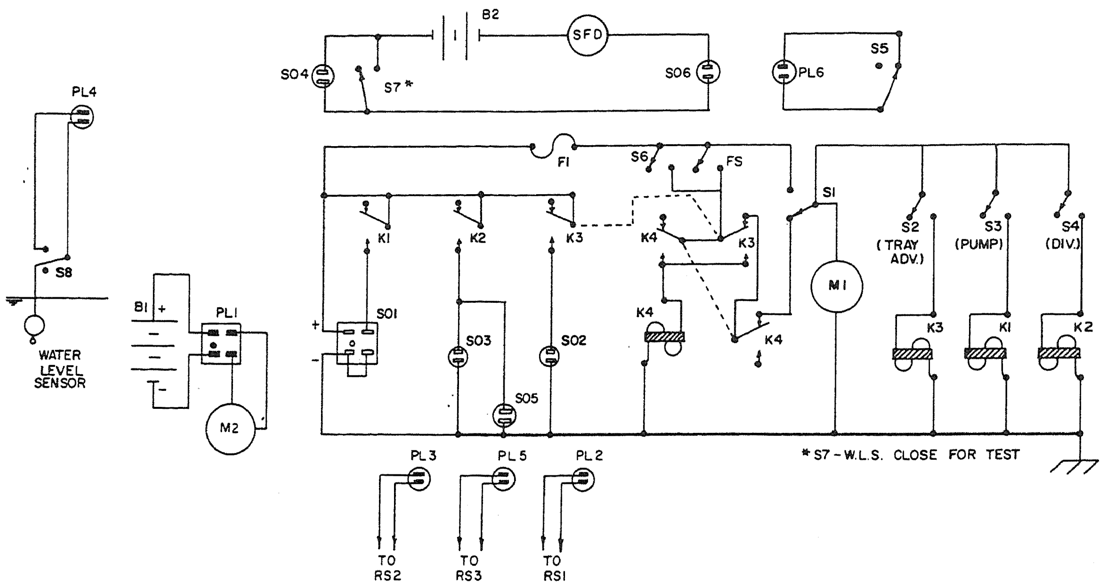
This procedure advances the tray and positions the bottle to accept the sample to be pumped. The weight that rotates the tray should be positioned to open switch S5 when the tray advances from bottle number 27 to bottle number 28, thus stopping operation of the sampler after sample number 28 has been pumped. Although the tray as shown holds 28 pint bottles, 24 quart bottles can be accommodated by repositioning properly sized holes in the ring and relocating 24 tray-advance bolts.

Figure 7 shows a layout of the timer, switches, and other electrical components. Figure 2 shows the electrical circuit diagram, the part numbers, and descriptions of all electrical components.

The diverter assembly, shown in figure 8, consists of a solenoid with an adapter that directs the pump discharge to a tubing assembly containing two outlets. The tubing assembly permits the discharge to be wasted or to flow into one of the sample bottles. It consists of two 6½-inch lengths of 1¼-inch rigid copper tubing, brazed as shown in the drawings. Each piece is flattened slightly on one end, providing a flat surface where the two tubes are joined. A ½-inch-square notch is cut in the flattened portion of the tubes to allow movement of the tube attached to the single-action solenoid. Two mounting bolts are brazed onto the tubing assembly.

The solenoid adapter is made from a 1-inch length of brass rod three-fourths inch in diameter. A 5/16-inch hole is drilled lengthwise through the brass rod to receive the solenoid shaft. Two 3/16-inch set screws hold the rod onto

(*Continued on page 12*)



ELECTRICAL PARTS SPECIFICATIONS

NOTATION	PART	DESCRIPTION
K1	PUMP RELAY	POTTER & BRUMFIELD PR 11DY - 12VDC
K2	DIVERTER RELAY	POTTER & BRUMFIELD KA 11DG - 12 VDC
K3	TRAY ADVANCE RELAY	POTTER & BRUMFIELD KA 11DG - 12 VDC
K4	TIMER MOTOR RELAY	POTTER & BRUMFIELD KA 11DG - 12 VDC
S01	POWER & PUMP SOCKET	CINCH - JONES S 404 - AB
PL1	POWER & PUMP PLUG	CINCH - JONES P 404 - CCT
S02	TRAY ADVANCE SOCKET	CINCH - JONES S 302 - AB
PL2	TRAY ADVANCE PLUG	CINCH - JONES P 302 - CCT
S03	DIVERTER SOCKET	CINCH - JONES S 302 - AB
PL3	DIVERTER PLUG	CINCH - JONES P 302 - CCT
S04	WATER LEVEL SENSING SOCKET	CINCH - JONES S 302 - AB
PL4	WATER LEVEL SENSING PLUG	CINCH - JONES P 302 - CCT
S05	CHART PIPPER SOCKET	CINCH - JONES S 302 - AB
PL5	CHART PIPPER PLUG	CINCH - JONES P 302 - CCT
S06	TRAY CUTOFF SOCKET	CINCH - JONES S 302 - AB
PL6	TRAY CUTOFF PLUG	CINCH - JONES P 302 - CCT
B1	BATTERY	AUTOMOTIVE WET CELL, 12 V, 80 AMP. - HR.
B2	BATTERY	D - SIZE DRY CELL, 1.5 VOLT
F1	FUSE	BUSS TYPE MDL 3 AMP. IN HKP BUSS HOLDER
S1	TIMER MOTOR SWITCH	
S2	TRAY ADVANCE SWITCH	SWITCHES LOCATED IN INDUSTRIAL
S3	PUMP SWITCH	TIMER (SEE M1)
S4	DIVERTER SWITCH	
S5	TRAY CUTOFF SWITCH	ROBERTSHAW BRD 2 - LW 8 - 1S
S6	MANUAL SAMPLE SWITCH	SPST SPRING-RETURN TOGGLE
S7	MANUAL WLS BYPASS SWITCH	SPST SPRING-RETURN TOGGLE
S8	WATER LEVEL SENSOR SWITCH	ROBERTSHAW BRD 2 - LW8 - 1S
FS	SAMPLING FREQUENCY SWITCH	CUTTER - HAMMER SW 54SA8380 - 4
SFD	SAMPLING FREQUENCY DRIVE 1/	MERCURY INSTRUMENTS CHART DRIVE, MODEL 99
M1	TIMER MOTOR	INDUSTRIAL TIMER CORP., MODEL MC-4, 12 VDC (4 - SWITCH TYPE WITH A - 12 GEAR RACK)
M2	PUMP MOTOR 2/	AJAX MODEL DC 1412, 1800 RPM @ 1/4 HP, 12 VDC
	PUMP 2/	RANDOLPH MODEL 500
RS1	TRAY ADVANCE ROTARY SOLENOID	LEDEX S - 8210 - 022
RS2	FLOW DIVERTER ROTARY SOLENOID	LEDEX S - 8204 - 024
RS3	CHART PIPPER ROTARY SOLENOID	LEDEX S - 8204 - 024

1/ UNNECESSARY IF LIGHT ACTIVATED UNIT IS USED.

2/ IF SEDIMENT LOAD IS LESS THAN 10% SAND, WESTERN BRASS WORKS PUMP - MOTOR MODEL 3 MPU MAY BE SUBSTITUTED FOR ECONOMY.

FIGURE 2.—Electrical schematic and electrical parts specifications.

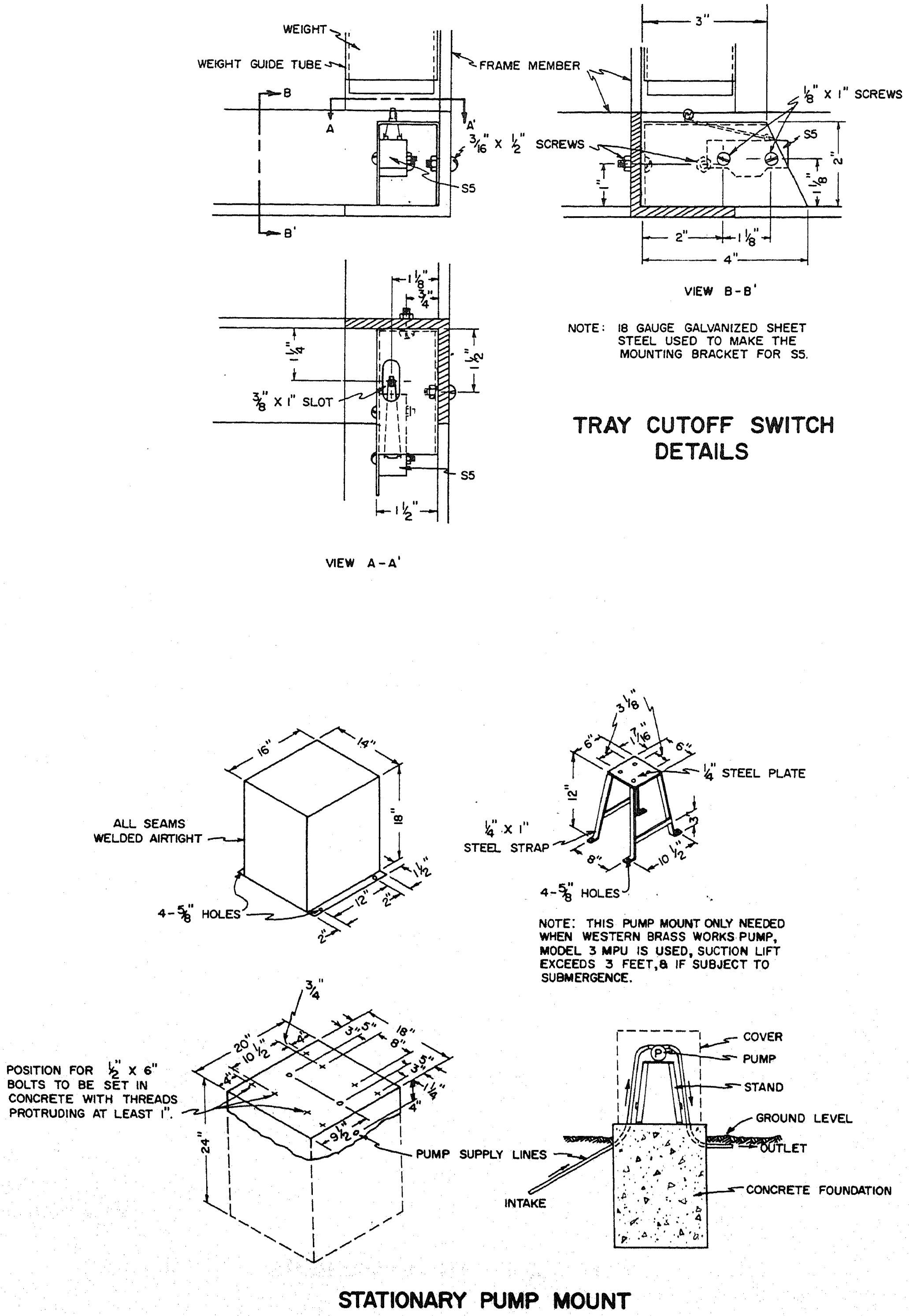


FIGURE 3.—Details of tray cutoff switch and stationary pump mount.

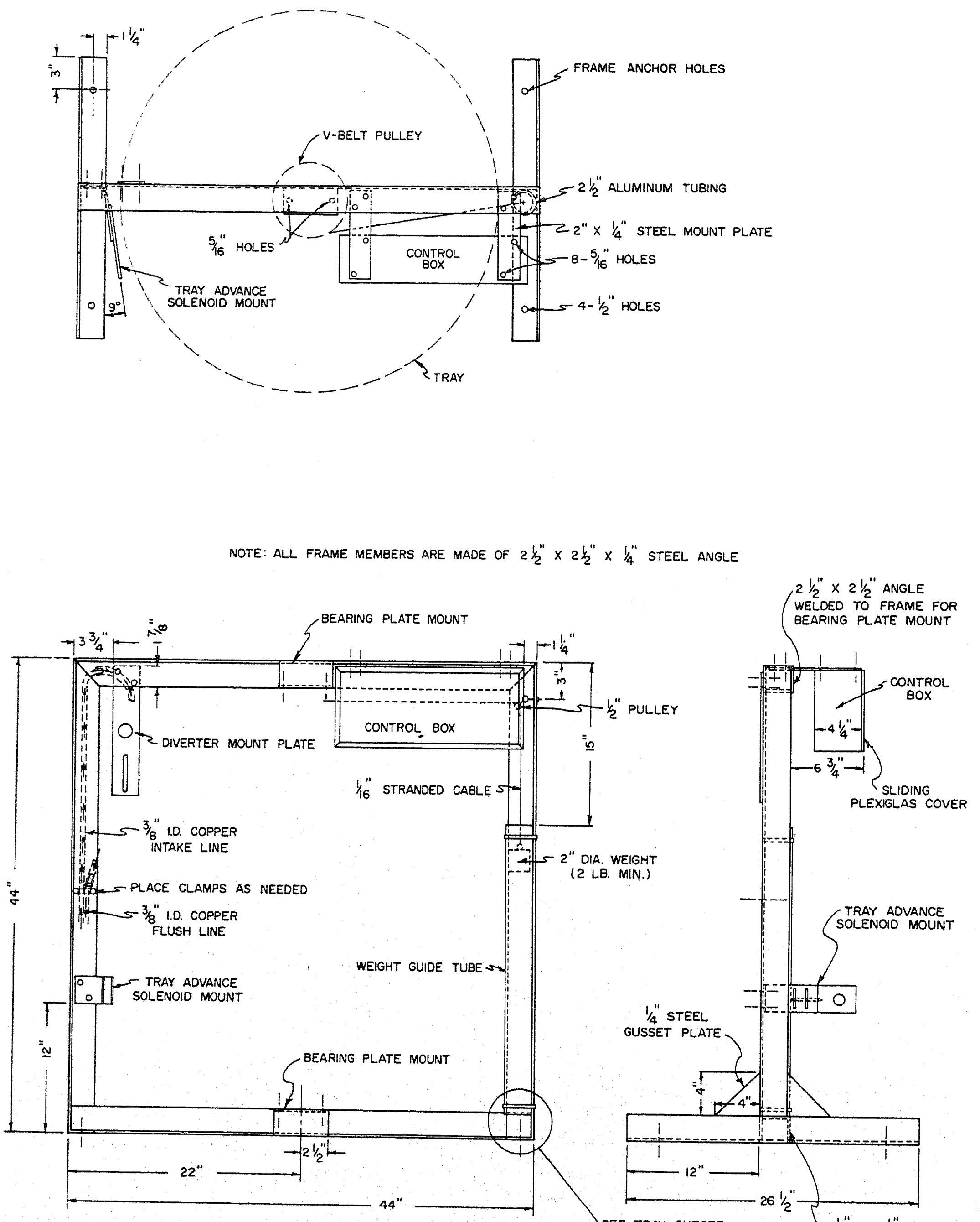


FIGURE 4.—Frame assembly with details.

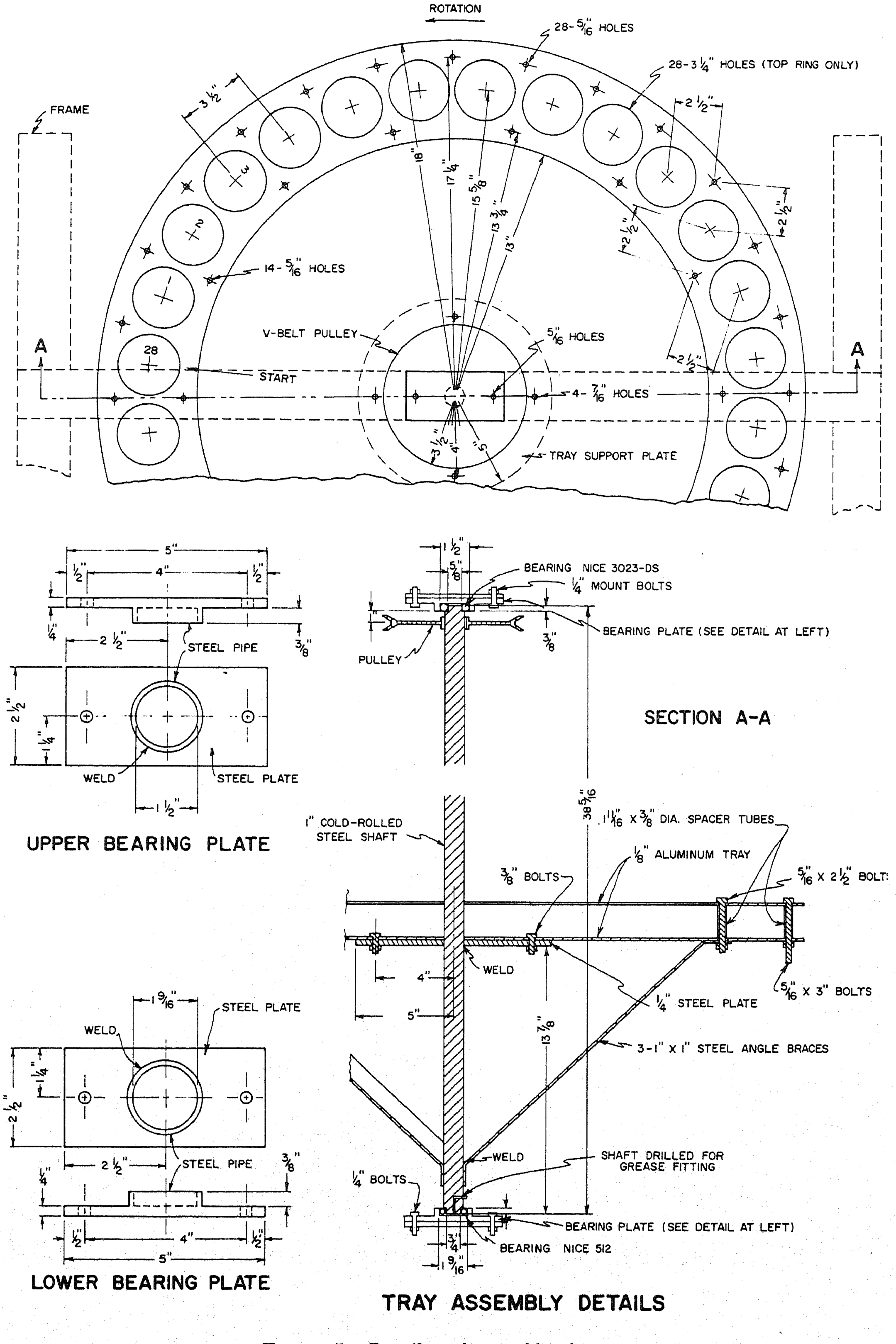


FIGURE 5.—Details and assembly of trays.

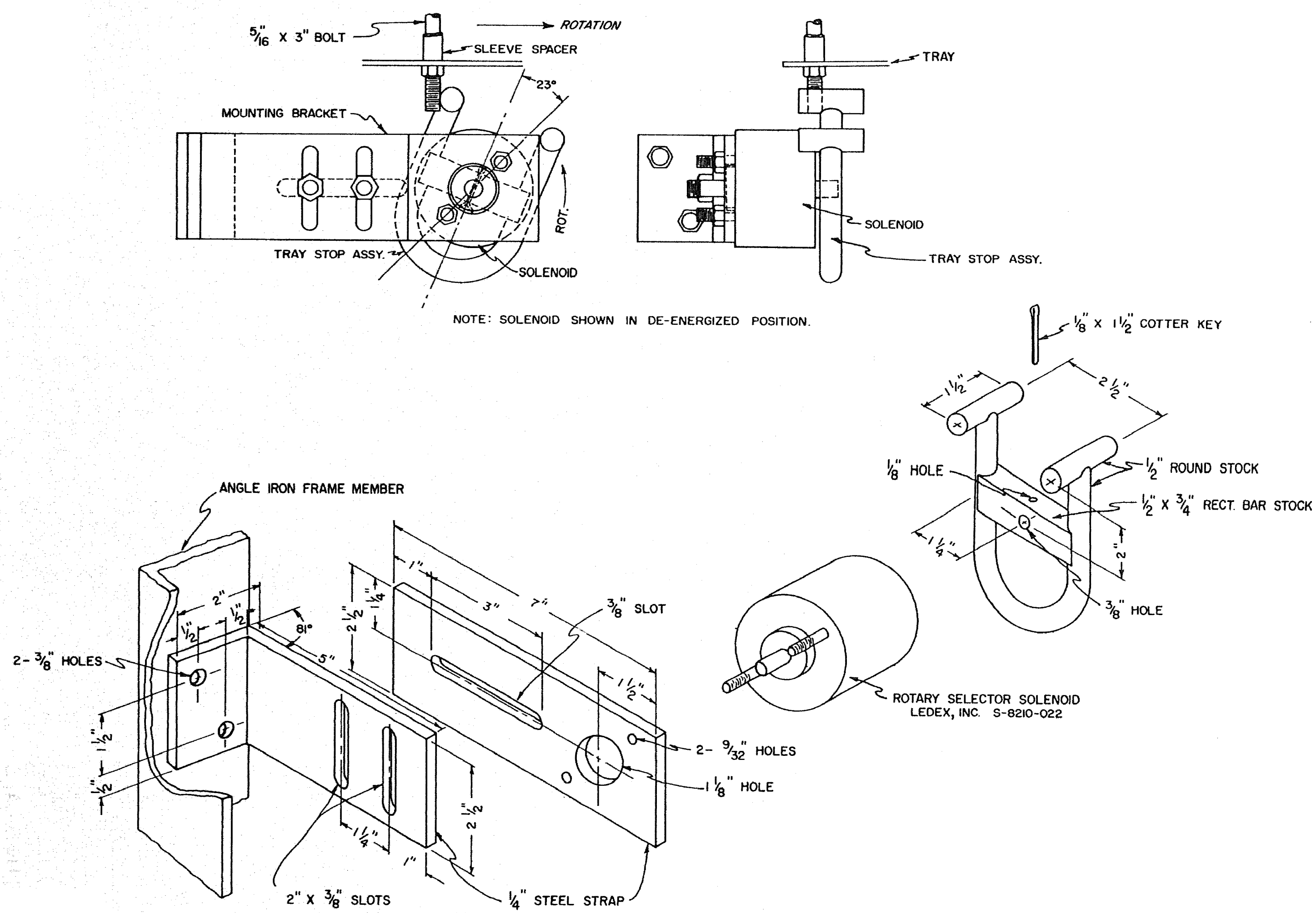


FIGURE 6.—Details of tray advance solenoid mount.

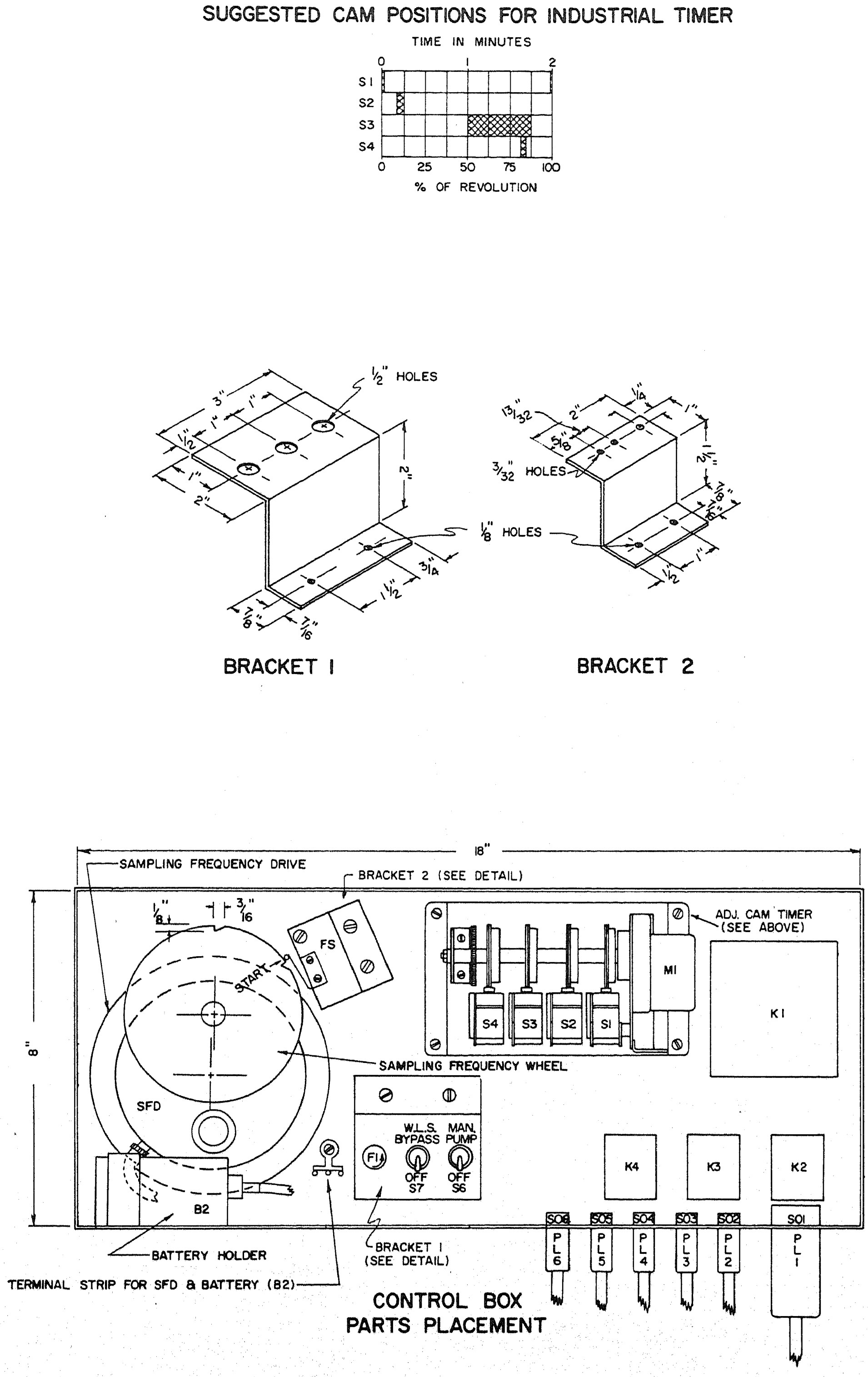


FIGURE 7.—Electrical control box parts layout and bracket details.

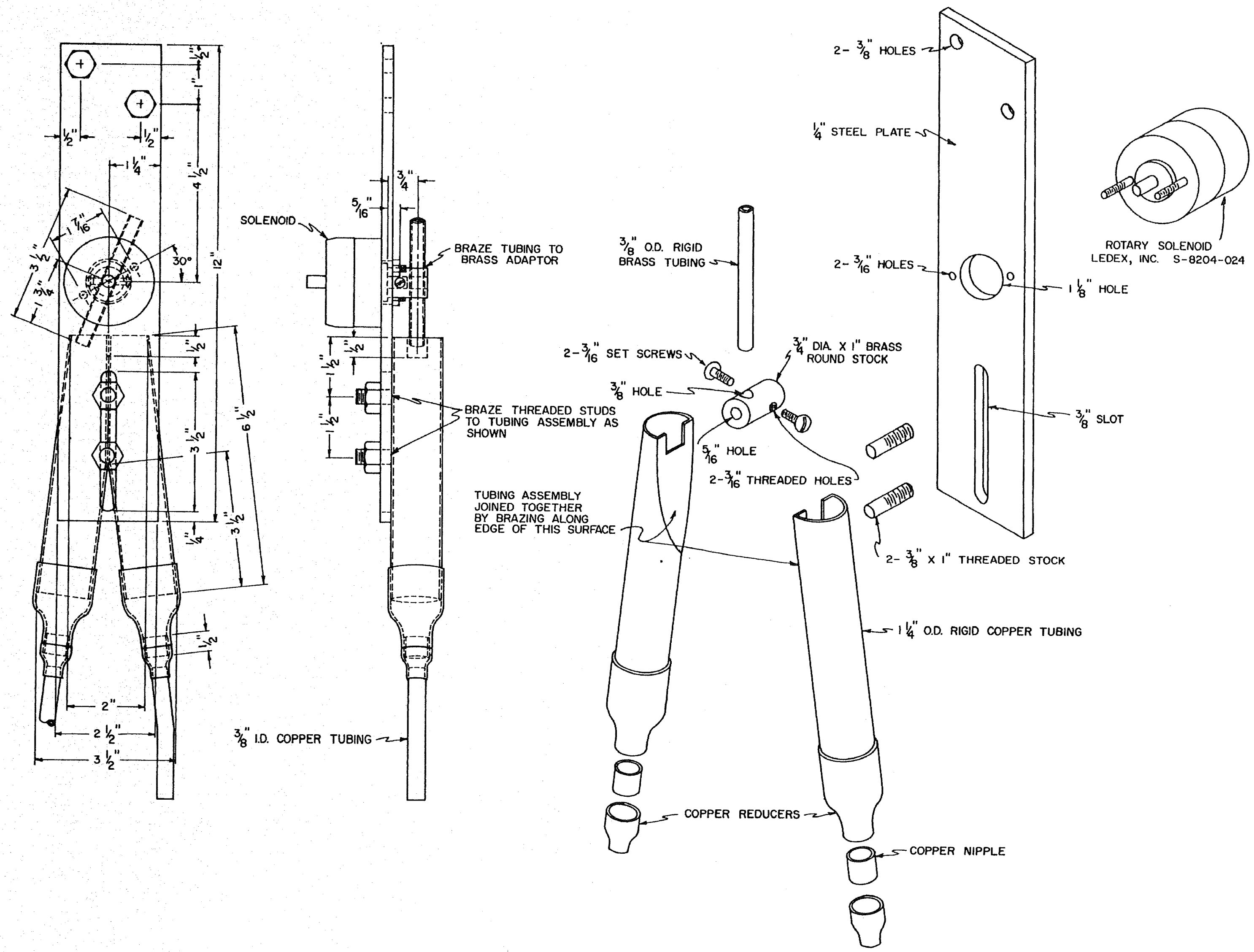


FIGURE 8.—Diverter assembly and details.

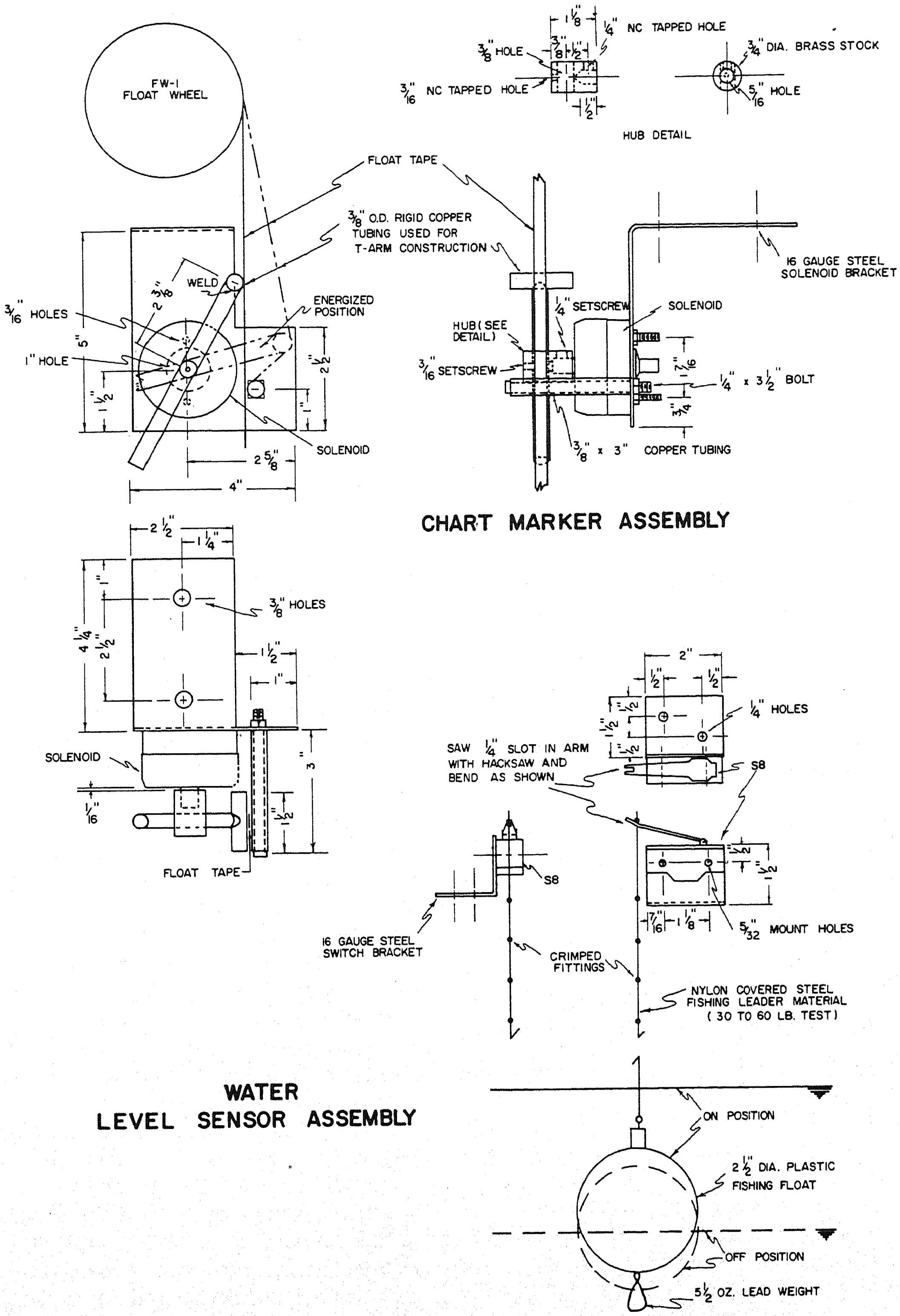


FIGURE 9.—Chart marker assembly and water-level sensor assembly.

the solenoid shaft. A 3½-inch length of tubing with an outside diameter of three-eighths inch is inserted through a ⅜-inch hole drilled through the outer end of the brass rod. The tube is brazed in place and the upper end connected to the pump discharge line by a flexible hose connection. The pump discharge will return to the stream when the solenoid is deenergized and will be diverted into a sample bottle when the solenoid is energized.

The sampling-frequency wheel (fig. 7) fits snugly over the shaft of the sampling-frequency drive (SFD). The ferruled nut supplied with the drive mechanism holds the wheel in place. Because the threads on the nut are recessed, the nut must be modified by cutting three thirty-seconds of an inch off its retaining end to allow it to tighten firmly against the timing wheel. Twenty-eight small notches are machined into the periphery of the wheel, one for each sample. The radial spacing of the notches controls the sampling frequency. A frequency interval of less than 10 minutes would require a larger timing wheel, because of the space needed to machine the notches. A study of hydrographs and sediment concentrations of previous stream rises can guide the selection of a sampling frequency for a particular station.

Collection of samples at 10-minute intervals required a slight modification of the sampling-frequency switch (FS), because notches could not be cut close enough together when using a switch with a 3/16-inch roller. This modification consisted of removing the 3/16-inch-diameter activator roller by cutting with small diagonal cutters. The roller-retaining pin was used as the activator roller. Drag caused by this change is of little significance.

Figure 9 shows a water-level sensor (WLS) used to start and stop the sampler. It consists of a weighted float, a nylon-covered suspension steel wire, and a switch (S8). The WLS may be installed in an existing gage well if there is enough room or in a separate well. The switch should be mounted in a sheltered place above the expected high-water level. One end of the wire is attached to the arm of the switch and the other is attached to a float, which must be heavy enough to open the switch. As the water level rises, the weight of the float assembly is reduced, permitting the switch to close and complete the circuit to the sampler. The float is positioned at the stage selected for the sampler to begin operating. This stage may be adjusted by attaching crimped fittings to the wire attached to the switch arm. A small slot is sawed in the end of the switch arm to permit the float to be raised or lowered to any desired elevation.

A second type of WLS that may be used consists of a waterproof mercury switch mounted in a pivoting Styrofoam float. As the water raises the float, the mercury switch closes and completes the circuit to the sampler.

A third type of WLS may be used with a water-stage servomanometer (bubble gage).[5] A switch is mounted on an adjustable bracket to the lower left of the mercury well which travels up and down on the threaded shaft. Another bracket with rounded ends and a flat, smooth surface facing the switch roller is mounted on the mercury well bracket. The switch is then adjusted up or down so that it will close at a predetermined water stage.

The chart marker (pipper) shown in figure 9 should be used with an FW–1 or A–35 water-stage recorder when a float-tape system is used. It consists of a rotary solenoid with a T-shaped bar mounted on the solenoid shaft. When the solenoid is energized, the T-bar strikes the float tape, causing the ink pen to move approximately one-fourth inch. Each time a sample is taken, a pip is made on the water-level chart. The T-bar can be adjusted for different pip lengths. The pip is used in plotting the sediment concentration after the samples have been analyzed.

A single-point intake suction line is used to collect samples from the flow. The intake is covered with a wire mesh screen to prevent trash from being sucked into the pump. The intake should be located so that as representative a sample as possible is collected.

The completed sampler should be housed in a relatively dust-free structure. The 80-ampere-hour battery specified in figure 2 will retain sufficient charge to operate the sampler after a standby period of approximately 30 days. The battery should be checked periodically with a hydrometer and recharged when the electrolyte specific gravity drops to 1.1200. To eliminate periodic battery charging, the Agricultural Re-

[5] Bubble Gage Installation and Service Manual. U.S. Geological Survey, October 1962, 66 pp.

search Service at Tucson, Ariz., is using a silicon solar cell charger with a mean daily charge rate of 0.34 ampere-hour to maintain the battery during standby periods.

The Chickasha sampler has proved to be effective and reliable for taking sediment samples automatically. Automatically pumped samples can mean the difference between a sedimentation record for a given runoff event or none at all.

The cost of a Chickasha sampler in 1975 was approximately $1,200, including $700 for materials and $500 for labor.

*1976-G.P.O.1750-S/671-583/43